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FORAGE PRODUCTION FROM ALONG INTERSTATE 90 IN NORTHEASTERN WYOMING

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ABSTRACT

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Medians and borrow areas of interstate highways in northeastern Wyoming can produce a dependable source of quality forage. These areas receive additional water from runoff, splash, and trapped snow, which may enhance plant growth. Fertilization with 80 lb/acre nitrogen and 56 lb/acre phosphorus produced significantly more forage than did the unfertilized check over a 3-year period. Crude protein, calcium, phosphorus, and magnesium in the plant material at the time of harvest was adequate for livestock nutrition. Lead content in the crested wheatgrass and yellow sweetclover ranged from 3.9 to 4.3 parts per million. These levels are not toxic to livestock.

KEYWORDS: Interstate highways, forage yield, crested wheatgrass, yellow sweet clover, fertilization, nitrogen, livestock nutrition, protein, Ca, Mg, P, Pb.

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FORAGE PRODUCTION FROM ALONG INTERSTATE 90 IN NORTHEASTERN WYOMING

By Frank Rauzi and Leland Landers[1]

INTRODUCTION

The vast acreages of land dedicated to our highway systems provide an opportunity to put the medians and borrow areas to productive use. The additional water received by the medians and borrow areas from the highway surface as runoff, splash, and trapped snow can insure a dependable hay crop (fig. 1). In some areas, the runoff obtained from the highway surface could be diverted to stock ponds or for beautification (Evans et al., *1975*).[2] In other areas, small grains or other cash crops could be grown.

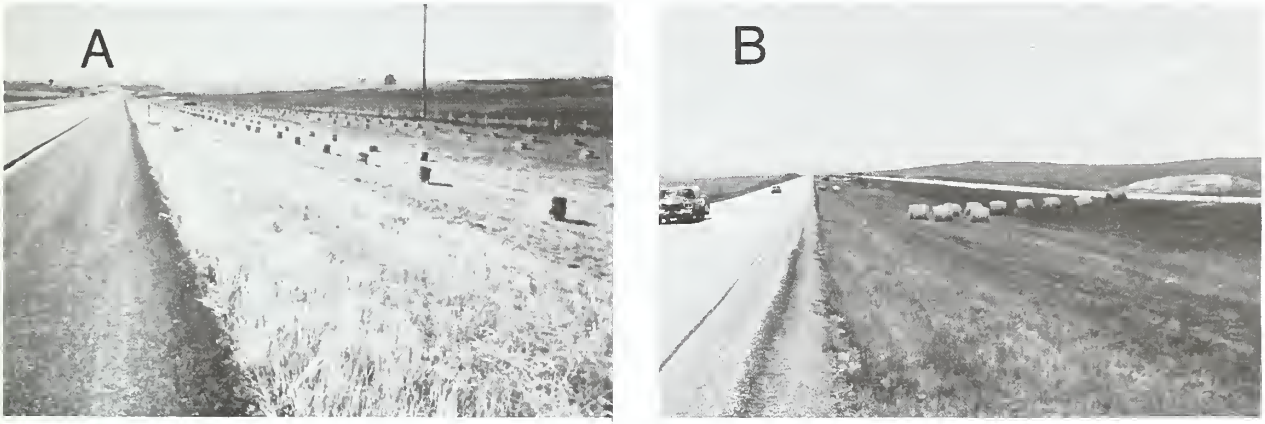

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FIGURE 1. — Forage harvested from (A) borrow area and (B) median near Buffalo, Wyo., 1978.

The highway departments in many States require the mowing of vegetation along highway shoulders to improve appearance, control weedy species, and keep snow from accumulating on the highway in winter. The medians and borrow areas may be seeded with a number of improved plant species that can serve to stabilize the roadside and furnish quality forage for livestock use and wildlife habitat. The management of such areas through proper fertilization and cutting practices can enhance the productivity of such sites.

In New Zealand, the highway right-of-way is referred to as the "long acre" (Catherine Scott, Wellington, New Zealand, personal communication), which is grazed by cattle and sheep (fig. 2). In some instances, electric fences are used or permission is obtained from the Borough to close a

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[1] Soil scientist, Science and Education Administration, University of Wyoming, Laramie, and Superintendent, Agricultural Substation, University of Wyoming, Gillette.

[2] The year in italic, when it follows the author's name, refers to Literature Cited, p. 10.

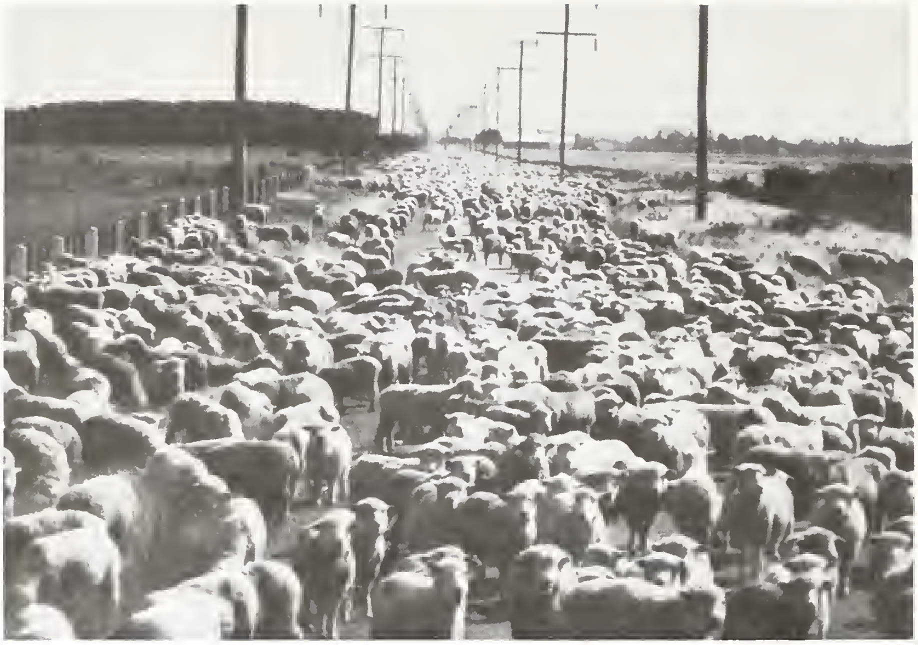

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FIGURE 2. — Sheep grazing the long acre in Wairarapa, New Zealand. (Photograph courtesy of Catherine Scott, Wellington, New Zealand.)

section of highway for a specified time so the livestock can graze the forage.

The study reported upon here was initiated in April 1974 to evaluate the effects of commercial fertilizer on quantity and quality of forage found in the medians and borrow areas of an interstate highway in northeastern Wyoming.

AREA

Considerable acreages are involved in the total interstate complex. In Wyoming, the right-of-way has a minimum width of 360 ft; in some places this width may be as much as 1,200 ft. The estimated average width of the right-of-way on Interstate 90 in northeastern Wyoming is 450 ft; thus, a typical mile of interstate highway could average 54.5 acres. The highway surface occupies 8 acres/mile, narrow medians 3 to 4 acres/mile, wide medians about 15 acres/mile, and the borrow areas average 23 to 31 acres/mile, depending upon the width of the medians and right-of-way.

PLANT SPECIES

After road construction is complete, topsoil is placed over the finished right-of-way before seeding. These areas are then mulched with straw at 2 tons/acre and fertilized with 40 lb/acre nitrogen. Topsoiling, mulching, fertilizing, and seeding the rights-of-way is a general practice used on the interstate highways in the Western States. A variety of native and introduced grasses and a legume have been seeded in the medians and borrow areas as sections of the highway were completed. Nordan crested wheatgrass *(Agropyron desertorum)* has been used extensively in the seeding. Because of its aggressiveness and early growth, crested wheatgrass soon becomes the dominant species. Yellow sweetclover *(Melilotus officinales),* a biennial, is often seeded because of its adaptability to a variety of sites. The Wyoming State Highway Department does not recommend including alfalfa in the seeding mixture, but it is often found in the right-of-way as a result of foreign seed being scattered from fields and vehicles. Once established, alfalfa persists.

CLIMATE

The climate at Gillette, Wyo., is classified as semiarid, temperate; the area is subject to wide and sometimes abrupt changes in weather. Normally, precipitation is lowest in February followed in turn by December, January, and November. The wettest months are April, May, and June, which account for nearly half the annual precipitation. Wind is frequent and strongest during the winter and spring months and generally blows from a northwesterly direction.

The 46-year (1931-76) annual, seasonal (April 1 to September 30), and monthly averages are presented in table 1. Seventy-one percent of the annual average precipitation is received between April 1 and September 30.

During the study period (1974-76), April, May, and June precipitation was 20.6 percent above the 46-year average for this period (table 1). Wet snows during April and May of 1975 and 1976 were largely responsible for the increase in precipitation. During April, May, and June, precipitation events of 0.10 inch or less accounted for less than 6 percent of the total precipitation during the study period.

Average annual snowfall (1956-75) is 62.7 inches with most of the snowfall occurring in the late fall and early spring months. Winter precipitation (October 1 to March 31) averaged 4.28 inches or 27 percent of the average annual precipitation (1956-75). Growing season averages 127 days per year (May 21 to September 25). The average annual temperature at the Gillette Substation is 45° with temperature extremes ranging from 107° to minus 40°.

TABLE 1. — *Monthly, seasonal, and annual precipitation, in inches, for 1974-76, and 46-year averages recorded at the Gillette substation in northeastern Wyoming*

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annnual	Seasonal[1]
1974	0.86	0.43	0.58	2.96	1.55	1.17	2.42	1.44	0.77	2.24	0.55	0.42	15.39	10.31
1975	.55	.33	.86	2.98	3.64	4.04	.72	.50	.05	1.06	.97	.70	16.40	11.93
1976	.64	.33	.59	2.10	2.68	5.05	1.29	1.41	.82	.88	.84	.32	16.95	13.35
3-yr average	.68	.36	.68	2.68	2.62	3.42	1.48	1.12	.55	1.39	.79	.48	16.25	11.86
46-yr average 1931-76	.61	.53	.95	1.87	2.38	2.98	1.26	.93	1.17	.91	.72	.59	14.90	10.59

[1] April 1 to Sept. 30.

STUDY SITE AND EXPERIMENTAL PROCEDURES

Replicated plots were established on two sites, a narrow median and a wide median. The borrow areas were approximately 2 and 4 miles west of Gillette, on Interstate 90. In April 1974, four plots, 50 by 104 ft, were established on the east and west side of a wide median; four plots, 50 by

32 and 50 by 40 ft, were established on the west and east borrow area, respectively. Four plots, 50 by 16 ft, were established on the north and south side of a narrow median. The plot areas were contiguous with the highway surface.

The major soil type in the area is Reno Hill clay loam, a member of the fine montmorillonitic mesic family of Ustollic Haplargids. In the construction of the interstate highway, soil materials from various depths and locations were mixed and compacted; thus, the soil on the disturbed areas bears little resemblance to the adjacent range soils.

Soil samples at 0- to 6- and 6- to 12-inch depths were obtained from three sites on the two borrow areas and the east and west side median. Soil samples were not obtained from the narrow median. Some physical and chemical properties of the mixed soils are shown in table 2. These properties varied with site, location, and depth. Soil textures ranged from sands to silty clay loams. The silty clay loam texture was determined by feel as these soils were saturated with gypsum and could not be dispersed. All other textures were determined by the hydrometer method (Bouyoucos, *1936*).

Soil pH ranged from 5.0 (strongly acid) to 7.8 (moderately alkaline). An electrical conductance of less than 2 micromhos per centimeter has a negligible salinity effect on plant growth (U.S. Salinity Laboratory Staff, *1969*); thus, for all practical purposes only the 0- to 6-inch soil depth on the east borrow and the lower end of the plot on the east median had electrical conductance that was high enough to affect plant growth.

Available phosphorus (sodium bicarbonate extractable) varied from 1.5 to 36.8 lb/acre. The lowest values were associated with the lower end of the plot, whereas, the highest values were found in the plots near the highway surface. A minimum of 10 lb/acre available phosphorus in the upper 6 inches of soil is considered to be near the deficiency level for a good grass growth; thus, several locations were low in available phosphorus.

Organic matter is an important source of nutrients and plays a major role in the tilth, infiltration, and physical characteristics of the soil. Organic matter was extremely variable, ranging from 0.2 to 5.7 percent. The highest value contained weathered coal fragments.

To assure adequate fertility, ammonium nitrate and phosphorus (treble super phosphate) were applied once in April 1974 to replicated plots at the rate of 80 lb/acre nitrogen and 56 lb/acre P_2O_5.

Forage yields were determined by harvesting three sites (approximately 2 to 3 ft from the highway surface, center of the plot area, and lower end of the plot area) the last week in June of each year.

Forage yields were calculated in pounds per acre at 12-percent moisture. Samples of crested wheatgrass were obtained from the center of the plot area for chemical analyses. Crested wheatgrass and yellow sweetclover were collected contiguous to and 15 ft from the highway surface in June 1976 for determination of lead concentrations in the plant materials. Crested wheatgrass and sweetclover were oven dried at 70° Celsius for 24 hours. Plant material was ground in a Wiley mill equipped with 40-mesh screen. Calcium, magnesium, and lead were determined by atomic absorption spectrophotometry on a perchloric acid digest. The molybdenum blue method (Dickman and Bray, *1940*) was used to determine percent phosphorus in 1974 and 1975. In 1976, phosphorus was determined by the Vanadomolybdophosphoric yellow color method in a nitric acid system (Method V) (Jackson, *1958*). Crude protein of the crested wheatgrass plant material was determined by the Kjeldahl procedure. Forage yields, crude protein, and mineral content data of the crested wheatgrass were analyzed by a split, split plot analysis. Duncan's multiple range test for significance was applied at the 5-percent probability level.

RESULTS AND DISCUSSION

During 1974 and 1975, crested wheatgrass was the dominant species on all sites, whereas, in 1976 sweetclover was dominant. Sweetclover was present as scattered plants on all sites in 1974 and increased in amount in 1975. In 1975, sweetclover growth on the fertilized plots averaged 4 to 6 inches high, apparently due to the lack of soil moisture.

Forage yields on the wide median declined with distance from the highway surface except for the east borrow nonfertilized and the west borrow fertilized (table 2). Forage yields from the fertilized and nonfertilized plots near the highway surface were significantly greater than the center or lower end of the plots except for the nonfertilized east borrow and fertilized borrow. Average forage yields for the 3 years were consistently higher on the fertilized than on the nonfertilized plots regardless of the site.

There were no significant differences in forage yields among years for the west borrow, east borrow, and east median of the fertilized plots, whereas significant differences existed among years and sites on the nonfertilized plots (table 3). The first year's (1974) forage yields on the nonfertilized plots were the lowest and the third year's (1976) were the highest because of the abundance of sweetclover. The normal cycling of sweetclover, a biennial, plus optimum conditions for germination and growth were present in 1976. When these conditions occur, sweetclover is abundant, and it may be referred to as a "clover year."

Overall average forage yields over the 3-year period from the fertilized plots (1,907 lb/acre) was significantly greater than from the nonfertilized plots (1,317 lb/acre) (table 3).

Forage yields from the narrow median were not obtained in 1974 because of a misunderstanding with the cooperator. The 1975-76 forage yields from the narrow median are shown in table 4. The overall average forage yields from the narrow medians, regardless of fertilization, were 105 percent greater than from the wide median. This large difference can be explained by the fact that more water is concentrated in a smaller area in the narrow median from rain, snow, and splash for plant use. The nonfertilized north plots of the narrow median produced an average of 973 lb/acre more forage than did the fertilized plots. The south fertilized plots produced 1,278 lb/acre more forage than did the nonfertilized plots over the 2-year period. Variation in the kinds and amounts of vegetation in the medians can account for the differences in the forage production. The stand of crested wheatgrass in the narrow median was not uniform. Colonies of bromegrass *(Bromus inermis)* and intermediate wheatgrass *(Agropyron intermedium)* were present in the narrow median.

Yellow sweetclover was not abundant in the narrow medians in 1975. In 1976, the sweetclover was more abundant on the north side than on the south side of the narrow median. Overall, a large portion of the forage produced in 1976 in the narrow median was from the sweetclover.

Crude Protein and Mineral Concentration in Crested Wheatgrass

CRUDE PROTEIN

Crude protein in the harvested crested wheatgrass varied among years and fertilization,

TABLE 2. — *Texture, pH, electrical conductivity, available phosphorus, and percent organic matter from 3 sites on the borrow areas and medians of Interstate 90, west of Gillette, Wyo., 1976*[1]

Site	Soil depth	Texture[2]			Paste pH			ECx10^3[3]			Phosphorus			Organic matter		
		H	M	B	H	M	B	H	M	B	H	M	B	H	M	B
	Inches								*Mmhos/cm*			*Lb/acre*			*Percent*	
West borrow	0-6	l	ls	sil	7.4	6.4	7.4	2.3	0.4	2.5	36.4	33.2	6.0	2.3	0.3	1.8
	6-12	sl	sicl[4]	sicl[4]	6.8	7.2	7.6	1.6	3.3	3.8	19.1	7.5	7.9	.3	1.9	1.5
East borrow	0-6	s	l	l	5.5	7.4	7.2	6.4	2.1	.6	31.0	27.5	8.9	.7	2.1	3.0
	6-12	s	l	l	5.0	7.5	6.8	.1	2.4	.4	32.8	8.9	1.5	.7	1.4	2.2
West median	0-6	s	sicl[4]	sil	7.2	7.4	7.6	.5	2.6	2.7	33.3	7.8	36.8	.8	1.7	5.7
	6-12	ls	sl	l	6.1	7.1	6.1	.4	3.0	3.8	30.6	7.1	9.2	.2	2.0	—
East median	0-6	sl	sl	sil	7.4	7.6	7.7	1.9	2.4	5.8	33.7	12.5	17.7	1.4	1.4	2.7
	6-12	sil	sic	sicl[4]	7.0	7.8	7.7	2.8	3.2	3.6	20.3	4.6	13.3	.5	.6	2.5

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[1] ls, loamy sand; l, loam; sicl, silty clay loam; sil, silt loam; sl, sandy loam; s, sand.

[2] H, plot area near the highway surface; M, center of plot area; B, bottom end of the plot area.

[3] Electrical conductivity.

[4] Texture was determined by feel.

TABLE 3. — *Hay yields at 12-percent moisture from wide median sites along Interstate 90, 4 miles west of Gillette, Wyo., harvested in late June 1974, 1975, and 1976*

Site	Year	H[1]	M	B	Avg.[2]
		No fertilizer			
		Pounds per acre			
West borrow	1974	939	950	242	707c
	1975	1,109	1,542	747	1,132b
	1976	2,572	3,067	1,244	2,294a
Means		1,540a	1,853a	744b	1,378
East borrow	1974	907	742	763	804c
	1975	1,244	1,830	1,100	1,391b
	1976	2,317	4,634	1,141	2,697a
Means		1,489b	2,402a	1,001b	1,631
West median	1974	998	471	707	725b
	1975	547	412	595	518b
	1976	5,732	1,111	1,371	2,738a
Means		2,426a	655b	891b	1,327
East median	1974	595	209	161	322c
	1975	1,723	323	323	789b
	1976	4,346	371	332	1,683a
Means		2,221a	301b	272b	931
Overall means		1,919	1,305	727	1,317
		Fertilizer[3]			
West borrow	1974	3,148	1,749	1,661	2,186a
	1975	1,542	2,250	1,694	1,829a
	1976	2,467	1,790	1,854	2,037a
Means		2,386a	1,930a	1,736a	2,017
East borrow	1974	2,334	3,112	1,746	2,397a
	1975	2,997	2,304	1,997	2,431a
	1976	4,195	2,797	1,584	2,859a
Means		3,175a	2,738a	1,776b	2,562
West median	1974	1,422	635	311	789b
	1975	2,293	1,146	1,335	1,591ab
	1976	4,244	987	640	1,957a
Means		2,653a	923b	762b	1,446
East median	1974	1,771	1,749	1,508	1,676a
	1975	3,593	1,161	1,324	2,026a
	1976	2,083	980	256	1,106a
Means		2,482a	1,297b	1,029b	1,603
Overall means		2,674	1,722	1,326	1,907

[1] H, plot area near highway surface; M, center of the plot area; B, bottom end of plot area.

[2] Means among locations and years column with the same letters are not significantly different at the 5-percent level, according to Duncan's multiple range test.

[3] 80 lb/acre N and 56 lb/acre P_2O_5 applied in May 1974.

TABLE 4 — *Hay yields at 12-percent moisture from a narrow median along Interstate 90, 2 miles west of Gillette, Wyo., with and without fertilizer, harvested in late June 1975 and 1976*

		No fertilizer[1]			Fertilized[2]		
Site	Year	H[2]	B	Avg.	H	B	Avg.
		Pounds per acre					
North narrow median	1975	2,030	5,113	3,571a	2,533	3,205	2,869a[3]
	1976	2,787	6,041	4,414a	2,629	3,711	3,170a
Means		2,408b	5,577a	3,992	2,581b	3,458a	3,019
South narrow median	1975	1,923	2,915	2,419a	2,167	3,999	3,083a
	1976	3,201	1,798	2,499a	4,974	3,811	4,392a
Means		2,562a	2,356a	2,459	3,570a	3,905a	3,737
Overall means		2,485	3,966	3,225	3,075	3,681	3,378

[1] H, plot area near the highway surface; B, bottom end of the plot area.

[2] 80 lb/acre N and 56 lb/acre P_2O_5 applied in April 1974.

[3] Means among location rows and years column with the same letters are not significantly different at the 5-percent level, according to Duncan's multiple range test.

but not among sites (table 5). The average crude protein content of the fertilized crested wheatgrass harvested in late June for the 3-year period was nearly the same for the fertilized and nonfertilized plots.

The interaction of years with sites on crude protein was significant as expected because of the variability among years. The crested wheatgrass was in mid- to full-bloom at time of harvest. Herbage growth is essentially completed by flowering time (Bedell, *1973*). The average crude protein of crested wheatgrass at this stage of growth is 8.7 percent (National Academy of Sciences, *1971*). Crude protein content of the crested wheatgrass harvested in mid-July 1974, 1975, and 1976 was 7.7, 6.9, and 7.9 percent, respectively, on the nonfertilized plots and 10.1, 6.4, and 7.7 percent, respectively, on the fertilized plots.

Differences in crude protein were higher the first year on the fertilized plots and higher on the nonfertilized plots the second and third years. Gom *(1964)* and Nichols and Johnson *(1969)* found a higher crude protein content of grass grown with sweetclover than with grass grown in pure stand. The average crude protein of crested wheatgrass harvested in late June was sufficient for most classes of sheep and beef cattle, whereas, the July harvest was deficient (National Research Council, *1968, 1970*).

CALCIUM

The calcium content of crested wheatgrass varied significantly among sites, years, and fertilizer treatments (table 5). Average calcium content of crested wheatgrass was significantly less the first year regardless of fertilizer treatments. The lower calcium values obtained the first year may have been the result of a drier growing season.

Between 0.22 and 0.34 percent calcium in the ration is required by sheep, 0.22 percent by beef cattle on high energy rations, and 0.18 percent in all other beef cattle rations (National Research Council, *1968, 1970*). The National Academy of Sciences *(1971)* reported that crested wheatgrass in mid- to full-bloom stage of growth should contain 0.22 percent calcium. Except for the first year of this study, the overall average calcium content of crested wheatgrass was greater than 0.26 percent and adequate for nutritional levels of sheep and cattle. The calcium content of crested wheatgrass harvested in mid-July 1974, 1975, and 1976, was 0.45, 0.43, and 0.43 percent, respectively, for the fertilized plots and 0.19, 0.45, and 0.45 percent, respectively, for the nonfertilized plots. Thus, except for the first year on the fertilized plots, calcium content was higher in July than in late June.

PHOSPHORUS

The phosphorus content of crested wheatgrass varied significantly among years, but not among sites or fertilizer treatments (table 5). The years by sites by treatment interaction on phosphorus uptake was significant, indicating that the three variables are not independent of each other. The phosphorus content of crested wheatgrass harvested in mid-July ranged from 0.17 to 0.27 percent on the fertilized plots and 0.22 to 0.23 percent on the nonfertilized plots. Overall, the phosphorus level did not change much between the harvest dates.

Phosphorus requirements for beef cattle have been reported to be 0.16 percent for dry pregnant mature cows (National Research Council, *1970*). For sheep, the phosphorus requirements range from 0.16 to 0.21 percent. Forage containing less than 0.16 percent phosphorus is considered to be deficient for gestating ewes and deficient if it contains less than 0.20 percent phosphorus for lactating ewes (National Research Council, *1970*). Thus, phosphorus was sufficient in crested wheatgrass in this study for sheep and cattle and higher than the 0.16 percent reported by the National Academy of Sciences *(1971)* for mid- to full-bloom stage of growth.

MAGNESIUM

The magnesium content of crested wheatgrass varied with site and treatment (table 5). The interaction of years by treatment was significant because of variability of years and effect of nitrogen on magnesium uptake. Magnesium content of the crested wheatgrass harvested in late June was more than adequate for sheep and cattle nutrition. The National Research Council *(1968, 1970)* has recommended 0.06 percent magnesium in the ration of an adult range ewe, 0.18 percent in the dry matter for lactating beef cows, and 12 to 30 milligrams per kilogram of body weight per day for beef cattle. The magnesium content of crested wheatgrass harvested in mid-July 1975 and 1976, on the nonfertilized plots was 0.11 and 0.12 percent on the fertilized plots. The change in magnesium content between the two harvest dates was negligible.

LEAD

Unusually high concentrations of lead in forage plants can be toxic to livestock. Under usual conditions, lead is sequestered in the bone; thus, it is removed from the human food cycle and is of no demonstrated importance to human health (National Academy of Sciences, *1974*). Crested wheatgrass samples were obtained from the center portion of the fertilized and nonfertilized plots on the four sites and were analyzed for lead content. Yellow sweetclover and crested wheatgrass growing contiguous to the highway surface (east median) were also analyzed for lead content.

The fertilized and nonfertilized crested wheatgrass lead content averaged 4.1 and 3.9 parts per million (p/m) (table 6). Crested wheatgrass growing contiguous to the highway surface had 4.4 p/m lead content, which is similar to the average lead content in the crested wheatgrass 50 ft from

TABLE 5 — *Percent crude protein, calcium, phosphorus and magnesium dry matter basis in fertilized and nonfertilized crested wheatgrass from along Interstate 90, 4 miles west of Gillette, Wyo., harvested in late June and mid-July 1974, 1975, and 1976*[1]

	Nonfertilized				Fertilized				
Ingredient and year	West borrow	East borrow	West median	East median	West borrow	East borrow	West median	East median	Avg.
					Percent				
Crude protein									
June 1974	7.9	7.7	7.7	8.6	10.6	11.3	12.0	11.8	9.7a
1975	10.2	10.0	10.6	10.3	8.6	8.6	9.4	8.9	9.7a
1976	8.3	11.3	8.7	9.2	8.8	8.9	8.8	8.9	9.1b
Means	8.8a	9.7a	9.0a	9.4a	9.3a	9.6a	10.1a	10.2a	
July 1974		7.7				10.1			
1975		6.9				6.4			
1976		7.9				7.7			
Means		7.5				8.1			
Calcium									
June 1974	.18	.31	.26	.28	.17	.23	.21	.20	.23b
1975	.29	.37	.36	.35	.31	.35	.36	.36	.34a
1976	.30	.41	.35	.35	.33	.35	.22	.35	.34a
Means	.26c	.36a	.32b	.33ab	.27c	.31b	.30bc	.30bc	
July 1974		.19				.45			
1975		.45				.43			
1976		.44				.43			
Means		.36				.44			
Phosphorus									
June 1974	.13	.14	.24	.26	.20	.18	.19	.25	.20b
1975	.24	.24	.21	.20	.22	.21	.22	.21	.22a
1976	.21	.25	.15	.17	.23	.23	.17	.22	.20b
Means	.19a	.21a	.20a	.21a	.22a	.20a	.19a	.22a	
July 1974		.23				.27			
1975		.23				.17			
1976		.23				.22			
Means		.23				.22			
Magnesium									
June 1975	.12	.17	.12	.09	.09	.10	.09	.09	.11a
1976	.13	.11	.12	.11	.13	.12	.13	.13	.12a
Means	.12ab	.13a	.12ab	.10c	.11bc		.11bc		
July 1974		.12				.12			
1975		.10				.12			
1976		.11				.12			
Means		.11				.12			

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[1] 80 lb/acre N and 56 lb/acre P_2O_5 applied in April 1974.

[2] Means among locations rows and year column with the same letter are not significantly different at the 5-percent level, according to Duncan's multiple range test.

TABLE 6 — *Lead content of crested wheatgrass and sweetclover (dry matter basis) from sites along Interstate 90, 4 miles west of Gillette, Wyo., harvested in late June 1976*

Site	Crested wheatgrass		Sweetclover	
	Fertilized	Non-fertilized	Leaves	Stems
	- - - - - - - - *Parts per million* - - - - - - - -			
West borrow, 50 ft[1]	4.4	4.7		
East borrow, 16 ft	3.7	2.8		
West median, 50 ft	4.2	3.9		
East median, 12 ft	4.3	3.4		
East median, 1 ft	—	4.4	2.5	2.5
East median, 15 ft	—	4.7	2.9	1.5
Average	4.1	3.9	2.7	2.0

[1] Approximate distance herbage samples were obtained from the highway surface.

the highway surface. In southern California, Page et al. *(1971)* have shown that the principal entry of lead into plants is from aerial deposits rather than absorption from the soil. When lead is incorporated in the soil, nearly all of it is converted into forms not available to plants (Ensminger,*1976*). Lead in the leaves and stems of sweetclover growing contiguous to the highway surface averaged 2.7 and 2.0 p/m, respectively. These concentrations would not be toxic to livestock; however, the effect of lead is cumulative. Thus, over an extended period, if no other forage were available, levels might accumulate that could be toxic. The lead content found in the forage at this location might be considerably less than for areas where the magnitude of traffic is much greater. Therefore, the extrapolation of lead content data to other areas might be hazardous.

Trash Problems

Some ranchers do not like to use the hay obtained from the borrows and medians because of the trash (cans, bottles, and so forth) that is picked up along some sections of the highway system. This problem can be greatly alleviated by enforcement of litter laws and the use of returnable containers. Another problem is the hazardous driving conditions that can result from wildlife being attracted to these areas by the presence of alfalfa, sweetclover, and green grass in the early spring and late fall. These areas are generally posted by the highway department as game crossings.

Harvesting Permits

A permit to harvest the forage within the highway right-of-way is obtained from the Wyoming State Highway Department. This permit is an agreement to assure that the harvesting is accomplished in a safe and efficient manner. The Wyoming State Highway Department encourages the contiguous landowner or other interested parties to harvest the available forage within the highway right-of-way as much as possible. These areas produce a greater amount of forage because the limited precipitation (rain, snow, and splash) is collected in the medians and borrows. Highways under construction and those planned for the future should be engineered for the best agricultural use of the area. Each year, 3 million acres of farmland are diverted to housing, shopping centers, industry, and highways. Thus, a significant portion of the highway system could be returned to agricultural use if the medians and borrow areas were used to grow a crop.

SUMMARY AND CONCLUSIONS

This study shows that the medians and borrow areas of the interstate highway in northeastern Wyoming can produce a dependable source of quality forage. Over the 3-year period, fertilizing with 80 lb/acre nitrogen and 56 lb/acre phosphorus produced significantly more forage than was produced by not fertilizing.

Crude protein of crested wheatgrass varied with years and fertilization. The abundance of sweetclover in the nonfertilized plots maintained the crude protein in the crested wheatgrass in these plots. Nichols and Johnson *(1969)* found soil nitrogen was significantly higher in plots on which sweetclover was grown.

Calcium and magnesium content of crested wheatgrass varied significantly among sites, years, and nitrogen treatments. Calcium and magnesium content of crested wheatgrass was more than adequate for livestock nutrition, except in 1974 when calcium was low.

Lead concentrations in crested wheatgrass or leaves and stems of sweetclover ranged from 2.8 to 4.7 p/m. Thus, the small amount of lead found in the plant material would not be toxic to livestock unless this was the only forage available over a long period of time. With the change to lead-free gasoline, lead may no longer be considered a problem.

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